Sodium-Ion Batteries
- Technology, Market Outlook, and SBIG Workstreams

A BCI SBIG White Paper / Briefing

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Prepared for SBIG members and stakeholders

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Document Scope and Disclaimer

Unless explicitly stated as 'SBIG synthesis', statements in this briefing are supported by cited sources.

- Purpose: Provide a neutral, technical and market-oriented briefing on sodium-ion batteries (SIBs) to support SBIG discussion, standards coordination, and commercialization readiness.
- Non-commercial: This paper does not endorse specific companies or products. Company mentions are illustrative and non-exhaustive.
- Conflict of interest disclosure: one of the authors is also an executive at QuantumShield Technologies, an early-stage U.S. sodium-ion company. To avoid commercial bias, this paper limits discussion of any single company and relies on third-party and SBIG-internal sources for factual statements.
- Sources and limitations: Market sizing and cost ranges vary materially by assumptions, cathode family, form factor, geography, and policy incentives. Where multiple sources disagree, ranges are presented.
- Not legal, tax, or investment advice.

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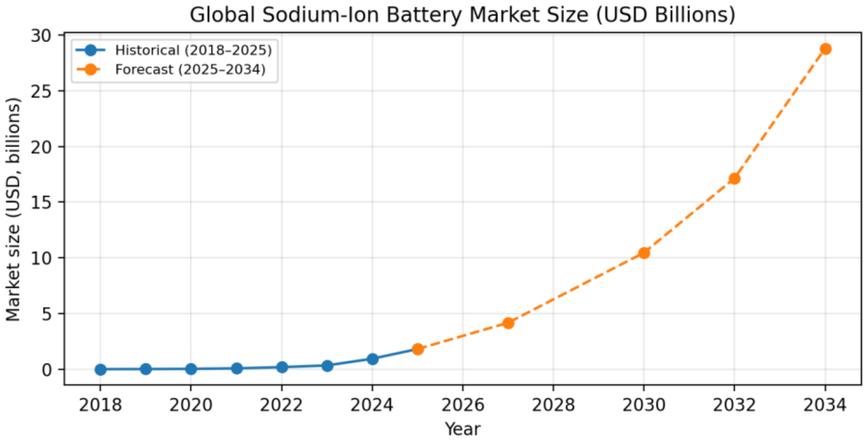
Executive Summary

- Sodium-ion batteries (SIBs) are positioned to complement lithium-ion and lead-acid batteries in applications where safety, cost stability, and supply-chain resilience are prioritized over maximum energy density.[2]
- Present-day commercial SIB performance ranges include ~90–160 Wh/kg gravimetric energy density, 500–8,000 cycle life, and operating temperatures from −40°C to +80°C depending on chemistry and duty cycle.[2]
- Thermal safety is strongly cathode-family dependent. A recent review of SIB cathode thermal stability highlights key runaway triggers—phase transitions, oxygen release, and cathode–electrolyte reactions—and summarizes mitigation levers including doping, surface coatings, lattice-water control, and electrolyte/interphase engineering.[16]
- Industrialization is accelerating: IRENA cites announced production capacity up to ~70 GWh/year by 2025 and nearly ~400 GWh/year by 2030; IRENA also notes that >95% of announced capacity is in China.[2]
- SBIG internal market synthesis projects the global SIB market rising from ~$0.95B (2024) to ~$28.8B (2034), with Asia-Pacific dominating early volumes and North America/Europe growing from smaller bases.[1]
- Competitiveness is sensitive to lithium prices and LFP cost declines. Roland Berger reports Na-ion vs LFP breakeven at ~USD 20–22/kg LCE for lithium carbonate equivalent (LCE) and notes Na-ion suitability mainly for micro/entry-level vehicles due to energy density limits.[3]
- Peer-reviewed techno-economic modelling across thousands of scenarios indicates that near-term (pre-2030) price advantage over low-cost Li-ion variants (especially LFP) is challenging in many cases; improving Na-ion energy density to reduce materials intensity and managing exposure to lithium/graphite/nickel supply-chain volatility are among the most impactful levers for competitiveness in the 2030s.[10]
- SBIG can accelerate adoption by harmonizing terminology/test conditions, issuing application qualification templates, clarifying safety/transport expectations, coordinating policy/standards engagement on 45X/48E and FEOC, and maintaining a neutral market tracker.

Figure ES-1. Global sodium-ion battery market size (historical and forecast). Source: SBIG internal market synthesis (Appendix A).[1]


Global Sodium-Ion Battery Market Size (USD Billions)
Historical (2018–2025)
Forecast (2025–2034)
Market size (USD, billions)
30
25
20
15
10
5
0
2018
2020
2022
2024
2026
2028
2030
2032
2034
Year

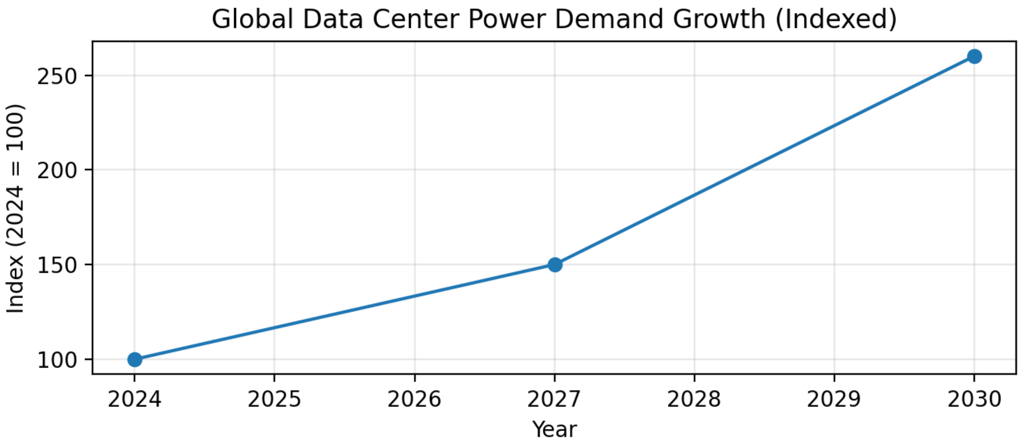
1. Strategic Context: Why Sodium-Ion Now

1.1 Demand drivers: grid, AI/data centers, resilience

Energy storage is increasingly required to firm renewable generation, provide ancillary services, and improve resilience. Supply-chain disruptions and geopolitical tensions have heightened interest in battery chemistries with broader material availability.[2]

Electricity demand from digital infrastructure is also becoming a major driver. Goldman Sachs estimates global data center power demand will rise ~50% by 2027 and ~160% by 2030, driven by AI workloads.[9]

Figure 1-1. Indexed global data center power demand growth. Source: Goldman Sachs.[9]



1.2 LDES and cost targets

DOE’s Long Duration Storage Shot aims for a 90% cost reduction for storage delivering 10+ hours, with a goal of ~$0.05/kWh by 2030.[7] This target emphasizes the need for scalable chemistries with lower materials cost floors and manufacturable system designs.

1.3 Positioning vs Li-ion and lead-acid

SIBs are broadly positioned between lead-acid and lithium-ion on energy density, with the potential to approach or match lower-end Li-ion in some future designs while leveraging abundant sodium precursors.[2] Their strongest near-term differentiation is typically framed around (i) raw-material availability, (ii) cold & High -temperature behavior, (iii) transport/safety characteristics, and (iv) cycle-life in certain duty cycles.[2][5]

2. Sodium-Ion Battery Primer

2.1 Architecture and operating principles

SIBs use reversible intercalation of Na+ between anode and cathode, analogous to Li-ion. During discharge, Na+ migrates from anode to cathode through the electrolyte while electrons flow through the external circuit; the process reverses on charge. [2][3]

A key design implication is sodium's larger ionic radius, which requires host structures with sufficient diffusion pathways and typically reduces achievable energy density relative to Li-ion for a given cell architecture.[2]

2.2 Materials system and cell design choices

Common cathode families include layered transition-metal oxides (TMO), Prussian blue analogues (PBA/PBW), and polyanionic compounds; most commercial designs use hard carbon anodes, and electrolyte systems often use NaPF6 or related salts in carbonate solvents.[2][5]

Cell architecture similarities mean SIBs can leverage existing Li-ion manufacturing knowledge (electrode coating, calendaring, formation, pack architectures), but chemistry-specific controls—especially moisture and water control for PBAs—can be critical.[5][13]

Table 2-1. Simplified comparison of main SIB cathode families (qualitative). Sources: [2][3]

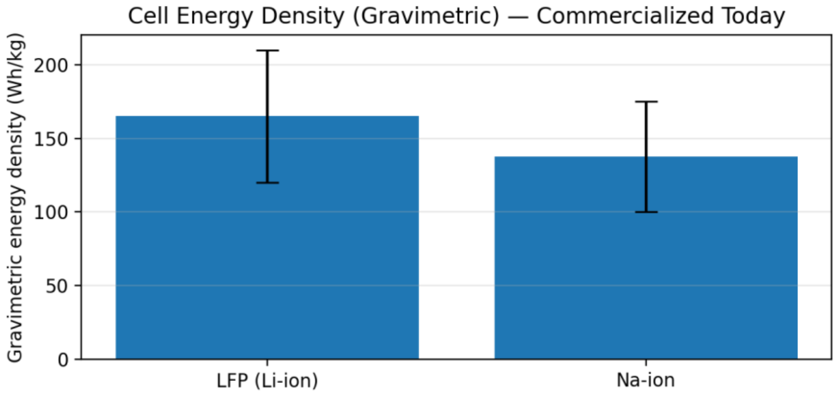
Cathode family	Typical focus	Pros (high-level)	Cons (high-level)	Examples (non-exhaustive)	Key manufacturing notes
Layered oxides (TMO)	Higher-energy mobility	Higher voltage/energy potential; leverage Li-ion base	Moisture sensitivity Low structural stability Low thermal stability Cost parity gap vs LFP	Na-Ni-Mn Na-Fe-Mn	Moisture control and surface coatings; air handling and QC important.[5][13]
Prussian blue analogues (PBA/PBW)	ESS / power / cold-temp	Fe/Mn-rich; good rate & cold performance; potentially low-cost	Water/vacancy control; Electrode density limits Volumetric energy	Prussian White	Strict control of water content/defects to achieve consistent voltage and cycle life.[5]
Polyanionic (e.g., phosphates)	ESS / safety-critical	High thermal stability; long cycle potential; cobalt/nickel-free	Lower voltage/energy; conductive network requirements	NFPP/NASICON variants	Potentially favorable for safety-critical stationary use; can trade energy for lifetime.[5]

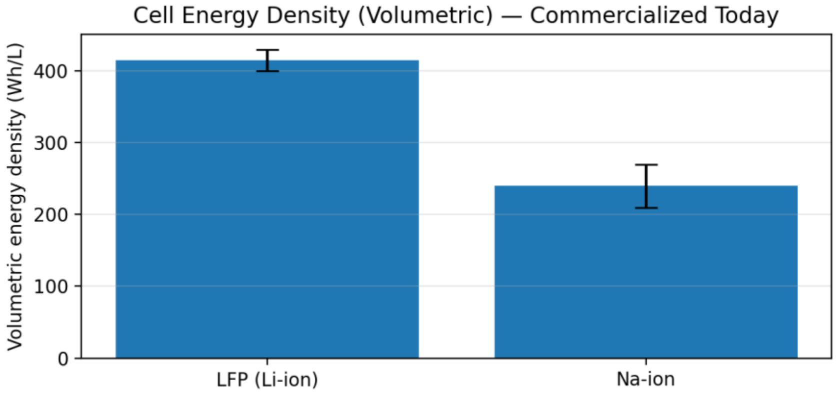
2.3 Performance envelope and safety considerations

IRENA summarizes present-day SIB performance ranges of ~90–160 Wh/kg, with some commercial announcements reaching ~175 Wh/kg and next-generation expectations of ~190–200 Wh/kg.[2]

SIBs can demonstrate excellent capacity retention at freezing temperatures and fast charging (e.g., 80% in ~15 minutes is cited for certain systems), but results depend strongly on chemistry, cell design, and test conditions.[2][5]

Figure 2-1 and Figure 2-2. Representative commercialized energy density ranges: LFP vs Na-ion. Source: Roland Berger.[5]





Safety and transport claims should be chemistry-specific. IRENA notes that SIBs may offer better abuse tolerance and may be safely transported fully discharged, especially for systems using polyanionic or PBA cathodes.[2]

2.4 Transport, handling, and bankability basics

For deployment at scale, performance claims must translate into bankable data packages: consistent cell/pack characterization, clear degradation reporting, validated safety tests, and supply-chain traceability. Logistics also requires compliance with transport testing (e.g., UN 38.3) and applicable stationary standards.[3]

3. R&D and Industrialization Trends

3.1 Cathode stabilization and water control

Polyanionic cathodes (incl. NFPP and NFS): In the internal report taxonomy, polyanionic cathodes are characterized by high thermal stability and long cycle life, supporting “high safety and stability” positioning.[1] The thermal-stability review notes that stable multi-anion frameworks can strengthen the lattice (e.g., via strong P–O bonding) and suppress high-temperature failure pathways, while also highlighting ionic-conductivity limitations as a recurring constraint.[16] Reflecting current China-side activity, Fe-based polyanions such as pyrophosphate / mixed phosphate-pyrophosphate (“NFPP” family, e.g., $Na_4Fe_3(PO_4)_2(P_2O_7)$) are widely studied for robust frameworks,[13] and fluorosulfates (NFS, e.g., $NaFeSO_4F$) are highlighted for inductive effects ($SO_4^{2-} + F^-$) enabling >3.8 V operation and higher decomposition temperatures in TGA versus conventional layered oxides.[16]

Prussian blue analogues (PBAs / “Prussian white”): PBAs are positioned in the internal report as lower energy density (100–140 Wh/kg) but very high cycle life (often cited at 10,000+ cycles), leveraging an open framework with fast Na^+ transport.[1] Practical performance is often limited by (a) water content (structural/lattice + adsorbed) and (b) framework defects/vacancies, which can drive side reactions and mechanical/structural damage during cycling; thermal stability is highly dependent on water content control.[16] A recent thermal-stability review details common control levers: thermal treatment and synthesis-process control to reduce water, and defect engineering to reduce $[Fe(CN)_6]^{4-}$ vacancies, including ligand/chelating strategies with reported reductions in water content and improved post-cycling morphology.[16]

Layered oxides (incl. $NaxMO_2$): Layered transition-metal oxides are the highest-energy-density pathway among the three mainstream SIB cathode families (~140–175 Wh/kg at cell level in the internal report framework).[1] Their key degradation/safety drivers include Na-extraction-induced phase transitions and (at high states of charge) increased reactivity that can couple to oxygen activity and electrolyte oxidation.[16] Stabilization strategies therefore emphasize (i) heteroatom doping (e.g., $Mg^{2+}/Ti^{4+}/Al^{3+}/Cu^{2+}$) to strengthen TM–O bonding and reduce thermally driven structural failure, (ii) structural modulation (interlayer spacing and strain accommodation) to manage phase evolution, and (iii) surface coatings to reduce cathode–electrolyte parasitic reactions and thermal stress at the interface.[16]

3.2 Hard carbon and electrolyte engineering

Electrolyte engineering is the parallel lever that largely determines interphase stability on both the hard-carbon anode (SEI) and cathode (CEI). IRENA notes that common liquid electrolytes for SIBs cells use sodium salts such as $NaPF_6$ or $NaClO_4$ in carbonate ester solvents (e.g., propylene carbonate), while research directions include alternative salts, additives, and solvent blends to widen stability windows and improve low-temperature behavior.[2] High-concentration and localized high-concentration electrolytes (HCE/LHCE) are frequently cited as promising because they can reduce free-solvent activity and promote inorganic-rich, mechanically robust interphases, improving Coulombic efficiency and suppressing continuous electrolyte decomposition under high rate or elevated temperature. In parallel, solid-state sodium electrolytes (e.g., NASICON-type ceramics, sulfides, and polymer/gel systems) are being explored for safety and potential energy improvements, but practical barriers remain—most notably interfacial impedance, processing/manufacturing complexity, and, for sodium-metal concepts, dendrite/short-circuit risk management.[2][12]

To improve ICE, cycle life, and manufacturability, academic and industry reviews emphasize process-control strategies such as precursor selection and purification, controlled pyrolysis temperature/time, and post-treatments (mild oxidation/reduction, pore engineering, and controlled carbon coating) to tune porosity while limiting surface reactivity. Biomass-derived hard carbons are a key direction for sustainable sourcing and potentially lower cost, but feedstock variability can drive batch-to-batch differences in ash content, heteroatom levels, pore structure, and tap density—creating reproducibility challenges as production scales. Consequently, scale-up programs often prioritize standardized feedstocks, in-line QC metrics (SSA, pore distribution, ash/metal impurities), and electrode-level controls (binder system, calendering, electrolyte wetting) to achieve consistent ICE and impedance growth.[12]

Hard carbon remains the predominant anode choice for today’s commercial sodium-ion cells because it can host Na^+ via multiple storage modes—surface adsorption, pore filling, and (pseudo-)intercalation within turbostratic carbon domains—where the balance among these modes is governed by microstructure. Key levers include (i) interlayer spacing and short-range ordering (affecting diffusion pathways and reversible capacity), (ii) the ratio of closed vs. open porosity and pore-size distribution (affecting low-voltage “plateau” capacity and rate capability), and (iii) specific surface area and surface functional groups (affecting electrolyte decomposition and SEI growth). Because SEI formation on high-surface-area carbons consumes sodium inventory, initial Coulombic efficiency (ICE) is particularly sensitive to surface chemistry and porosity; electrode density/compaction is also important because low tap density can penalize volumetric energy and manufacturing throughput.[12]

3.3 Next-generation trajectories (190–200 Wh/kg and beyond)

IRENA reports manufacturer expectations that next-generation SIB cells may exceed ~190–200 Wh/kg, and notes announcements of ~175 Wh/kg designs planned for mass production in 2025.[2] Roland Berger’s analysis indicates that layered oxides are the most likely path to automotive energy-density targets but may face cost-parity gaps versus LFP without significant development.[5]

3.4 Thermal stability of SIB cathodes (materials-to-cell)

Cathode materials are a primary driver of thermal behavior in sodium-ion cells under abuse or high-temperature conditions. A 2025 review emphasizes that elevated temperatures can induce cathode phase transitions and oxygen release, accelerating structural degradation and heat generation; cathode–electrolyte reactions can then produce flammable gases, increasing the risk of thermal runaway.[15]

The same review reports indicative comparative temperatures at identical state-of-charge: self-heating onset of ~102°C for SIBs versus ~89°C for LIBs; thermal runaway initiation at ~221°C (SIB) versus ~191°C (LIB); and a lower peak thermal runaway temperature for SIBs (~407°C) compared with LIBs (~695°C). These values are chemistry- and design-dependent but provide an evidence-based directional comparison.[15]

Cathode-family mechanisms (selected examples): (i) layered oxides—phase transitions and oxygen instability dominate, especially at high voltage; (ii) tunnel-type oxides—Mn disproportionation and Jahn–Teller effects can contribute to instability; (iii) polyanionic compounds—rigid anionic frameworks generally improve intrinsic thermal stability, with risks shifting toward interface/CEI behavior; (iv) Prussian blue analogues—water content and vacancy density strongly influence thermal stability and gas evolution.[15]

Test and characterization methods widely used for cathode thermal stability include accelerating rate calorimetry (ARC) for cell-level temperatures (self-heating onset, runaway threshold, peak temperature), and DSC/TGA (optionally coupled with MS) for material-level enthalpy and gas evolution. SBIG can use this materials-to-cell framing to define minimum qualification test matrices by application segment.[15]

Figure 3-1. Indicative thermal safety temperatures (SIB vs LIB) at equal SoC. Source: Wang et al. review.[15]

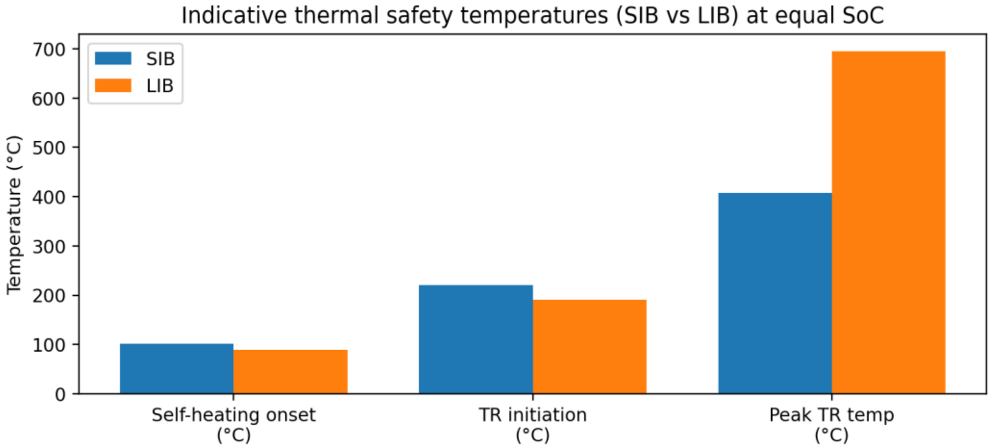


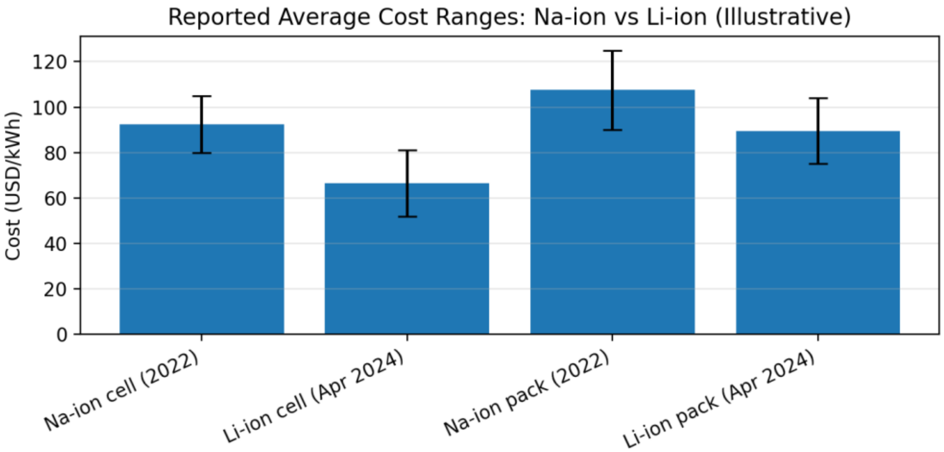
Table B-1 (Appendix B) provides a cathode-family summary of dominant thermal runaway causes and influencing factors.[15]

4. Cost and Competitiveness

4.1 Baseline cost ranges and learning curves

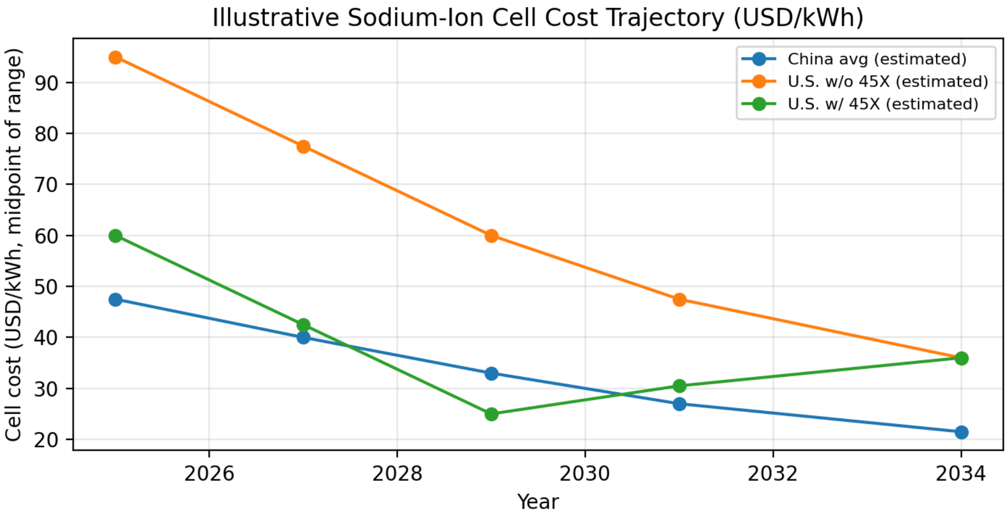
Cost benchmarks vary by year, geography, and chemistry. IRENA reports average SIB cell costs in 2022 of ~USD 80–105/kWh (packs ~USD 90–125/kWh), compared with Li-ion cell costs in April 2024 of ~USD 52–81/kWh (packs ~USD 75–104/kWh).[2]

Figure 4-1. Reported average cost ranges: Na-ion vs Li-ion (illustrative). Source: IRENA.[2]



An SBIG internal market synthesis estimates a cost trajectory in which China-average Na-ion cell cost declines from ~USD 40–55/kWh (2025) toward ~USD 18–25/kWh (2034), with U.S. costs depending strongly on policy incentives and scale.[1]

Figure 4-2. Illustrative Na-ion cell cost trajectory (midpoints of ranges). Source: internal market synthesis.[1]



4.2 Lithium price sensitivity and LFP benchmark

Competitiveness is sensitive to lithium price levels and LFP innovation pace. Roland Berger states that Na-ion vs LFP breakeven corresponds to ~USD 20–22/kg LCE; below this, LFP (or LMFP) is often preferred on cost/performance.[3]

From a mobility perspective, Roland Berger notes Na-ion is being explored mainly for entry-level micro cars (A0 segment) and is constrained by energy densities (maximum ~160 Wh/kg or ~400 Wh/L in their summary).[3]

Peer-reviewed analysis in Nature Energy assesses Na-ion techno-economic competitiveness against Li-ion using a modelling framework that combines floor-constrained component learning curves with cell design roadmaps across >6,000 scenarios. The authors conclude that being price advantageous against low-cost Li-ion variants in the near term is challenging in many scenarios, and that improving Na-ion energy density (reducing materials intensity) is one of the most impactful levers to accelerate competitiveness.[10]

The same study highlights high sensitivity to critical supply-chain conditions—especially lithium price levels as well as potential graphite or nickel supply disruptions—and cautions that system-level effects (e.g., pack integration or thermal management savings) are not captured in cell-level comparisons.[10]

Implication for SBIG: benchmarking Na-ion against an LFP “moving target” requires (i) transparent test conditions and reporting conventions, (ii) realistic roadmaps for energy-density and yield improvements, and (iii) scenario-based evaluation tied to supply chain assumptions.[10]

4.3 Role of policy incentives (45X/48E) and FEOC compliance

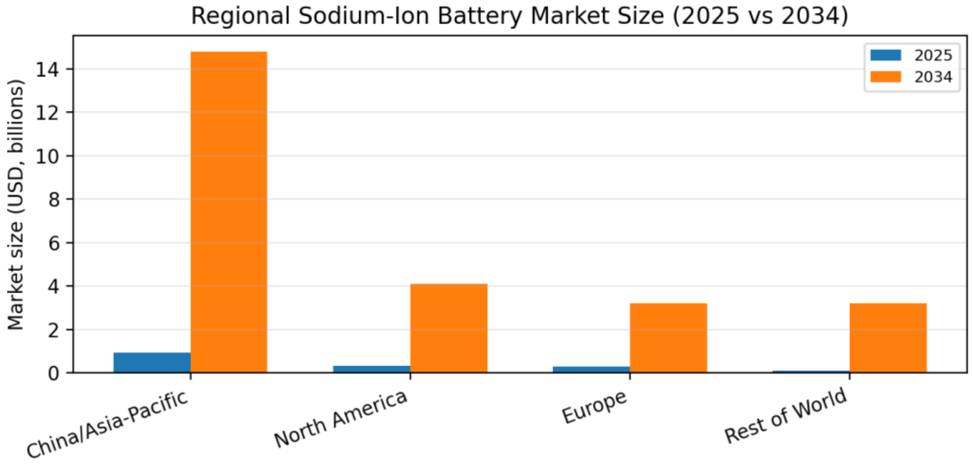
Post-OBBBA, EV consumer tax credits (30D, 25E, 45W) are cancelled as of 9/30/2025, while production tax credits (45X) and storage ITC (48E) remain relevant with new prohibited foreign entity (FEOC/PFE) requirements for eligibility.[4][15]

5. Market Outlook and Adoption Scenarios

5.1 Market sizing (global and regional)

SBIG internal synthesis projects global SIB market size rising from ~$0.95B (2024) to ~$28.8B (2034), with Asia-Pacific growing from ~$1.09B (2025) to ~$18.3B (2034) in one scenario, and North America from ~$0.33B (2025) to ~$4.1B (2034).[1]

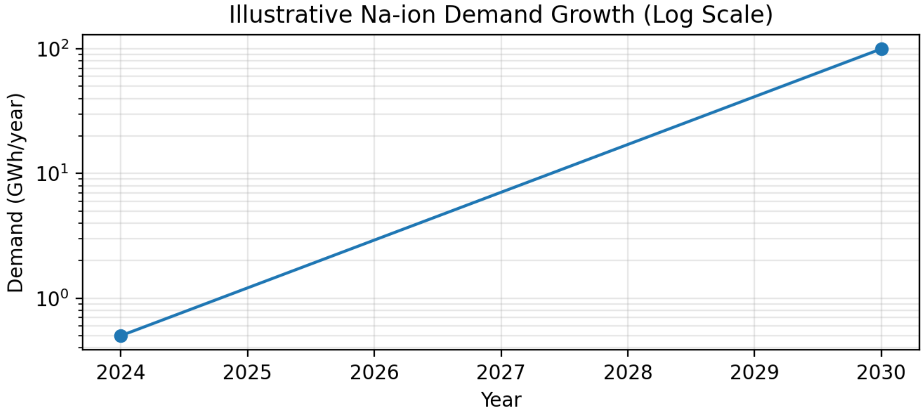
Figure 5-1. Regional market size (2025 vs 2034). Source: internal market synthesis.[1]



5.2 TAM and demand forecasts (to 2030)

Demand forecasts vary. IRENA cites a broad range of 50–600 GWh/year by 2030 across scenarios, while Roland Berger's model indicates Na-ion demand increasing to at least ~100 GWh by 2030 (with potential for higher if ESS demand accelerates).[2][5]

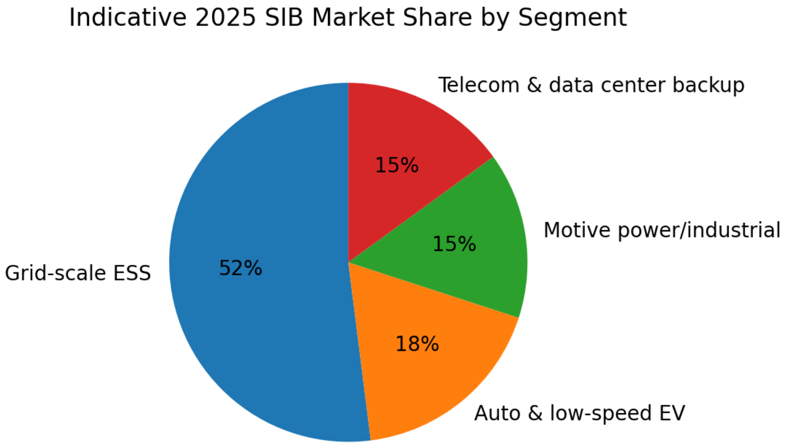
Figure 5-2. Illustrative Na-ion demand growth to 2030 (log scale). Source: Roland Berger (TAM model).[5]



5.3 Segment view: ESS, mobility, telecom/data centers, motive power

One internal segmentation attributes 2025 SIB market share approximately to grid-scale ESS (52%), automotive/low-speed EV (18%), motive power & industrial (15%), and telecom/data center backup (15%).[1]

Figure 5-3. Indicative 2025 market share by segment. Source: internal market synthesis.[1]



6. Supply Chain and Critical Materials

6.1 Sodium precursors and soda ash

SIB manufacturing commonly relies on soda ash (sodium carbonate) as a sodium precursor. IRENA notes natural soda ash resources are estimated at ~47 billion tonnes (reserves ~25 billion tonnes) and that soda ash can also be produced synthetically from salt and limestone.[2]

Despite the raw-material abundance, manufacturing and processing capacity is geographically concentrated. IRENA notes that over 95% of announced SIB production capacity is in China.[2]

6.2 Equipment and intermediate materials

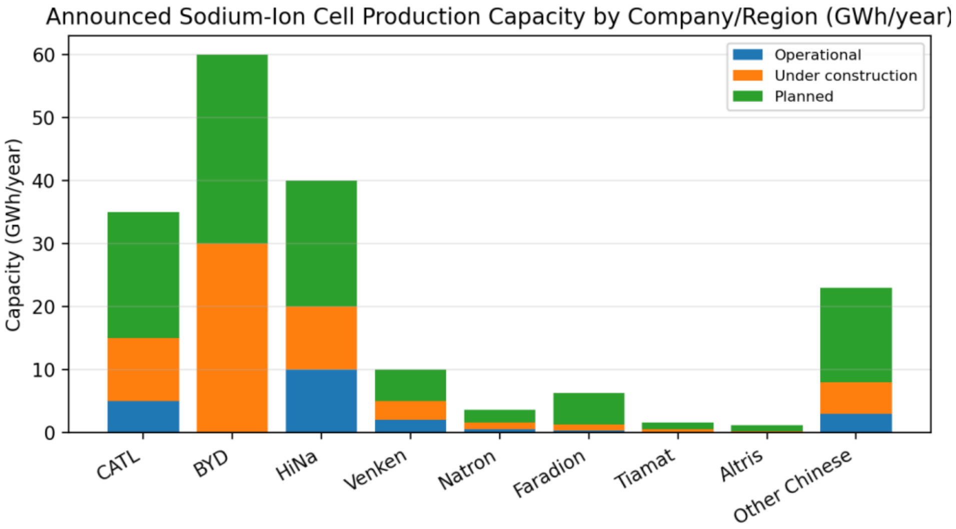
Beyond sodium precursors, key supply-chain nodes include hard carbon feedstock and processing, electrolyte salts, separators, and manufacturing equipment (coaters, calendaring, formation, dry-room systems). Export controls and tariffs can affect these nodes, and North American localization strategies must account for equipment and process know-how.[4][5]

7. Manufacturing Landscape and Ramp-up Risks

7.1 Capacity landscape

Capacity announcements indicate rapid scale-up led by Chinese incumbents, with smaller early-stage lines in Europe and North America. SBIG internal synthesis estimates ~21 GWh/year operational capacity and ~160 GWh/year under construction or planned across a set of named players (illustrative and subject to change).[1]

Figure 7-1. Announced sodium-ion production capacity by company/region (illustrative). Source: internal market synthesis.[1]s

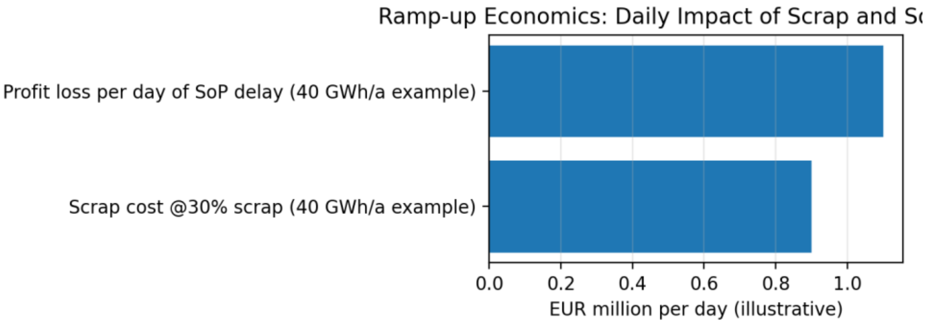


7.2 Ramp-up economics: yield, scrap, and delays

Manufacturing ramp-up often dominates time-to-volume and initial cost. A ramp-up white paper summarizes reported scrap rate ranges of ~15–30% in the first years of battery production and notes that scrap rates around ~10% can persist after five years in some datasets.[6]

At a 40 GWh/year scale, the same analysis estimates ~€0.9M/day scrap costs at 30% scrap rate and ~€1.1M/day profit loss per day of start-of-production delay (illustrative).[6]

Figure 7-2. Ramp-up economics: daily impact of scrap and SoP delay (illustrative). Source: RWTH Aachen / Fraunhofer FFB.[6]



7.3 SBIG manufacturing KPI playbook (proposed)

A non-proprietary KPI playbook could include: incoming materials QC (particle size, moisture), electrode coating uniformity, calendaring density windows, formation protocols, water/oxygen control limits, yield and rework categories, warranty return tracking, and incident/near-miss reporting. The goal is to shorten learning loops without sharing trade secrets.[3][6]

8. Applications and Deployment Pathways

8.1 Grid and behind-the-meter ESS

ESS is widely cited as the lead segment for near-term SIB adoption given less stringent energy-density constraints than long-range EVs. IRENA notes market penetration will depend on efficient scale-up while matching Li-ion cost and energy density.[2]

8.2 Telecom and data center backup

Telecom and data center operators are replacing legacy VRLA systems; an internal SBIG report notes SIBs may offer longer cycle life and lower maintenance with improved footprint versus VRLA, subject to qualification cycles.[1]

Data center power demand growth (+160% by 2030) increases the relevance of resilient power and storage solutions at multiple scales.[9]

8.3 Motive power and cold-chain logistics

Motive power (forklifts, AGVs) and cold warehouses are frequently cited for SIB differentiation because cold-temperature performance and cycling durability can translate to uptime and TCO benefits.[1][2]

8.4 Micro/low-speed EV and low-voltage automotive auxiliary

Roland Berger notes that in China, few SIB-based vehicles have launched and they are mostly smaller A-segment platforms; Na-ion is also viewed as a hedge against high lithium prices and as a candidate for low-voltage auxiliary/starter batteries for low-temperature performance.[5]

Table 8-1. Indicative application fit matrix (non-exhaustive).

Application segment	Primary value drivers	Key constraints	Readiness (2026–2028)	Notes / SBIG needs
Grid / utility-scale ESS	Cost stability; supply resilience; safety; 4–10+ hour storage	Bankability, warranty, project financing; volumetric footprint	Medium	Standardize test conditions and degradation reporting; align with UL/IEC pathways.[2][7][15]
Telecom & data-center backup	Reliability; lower maintenance; footprint; cold-temp	Qualification cycles; vendor approval; transport rules	Medium	Define qualification templates and safety guidance for backup use-cases.[1][9]
Motive power (forklifts, AGVs)	High cycle; fast charge; cold warehouse	TCO vs LFP; charging ecosystem integration	Medium	Define duty-cycle profiles and state-of-safety monitoring approaches.[1][11]
Micro / low-speed EVs	Cost; cold-temp; acceptable range	Energy density vs range; OEM validation	Medium (China-led)	Harmonize SOC/SOH, fast charge and low-temp protocols.[5]
Low-voltage automotive auxiliary	Cold crank, deep discharge tolerance	OEM validation; standards alignment	Emerging	Opportunity to align with BCI low-voltage standards and test methods.[5]

9. Policy, Standards, and Bankability Considerations

Post-OBBBA changes remove several EV-focused credits while keeping 45X and 48E for manufacturing and storage projects, with added prohibited foreign entity (PFE/FEOC) requirements and documentation expectations.[4][15]

For stationary systems, bankability requires consistent performance and safety documentation. SBIG can support by developing standardized reporting templates, aligning on accelerated-aging protocols, and mapping applicable standards (UL/IEC/IEEE) to key application segments.[3]

10. Recommended SBIG Workstreams (2026–2027)

A. Terminology and Test Harmonization

Create SBIG guidance for terminology, reference duty cycles, and reporting formats for degradation and safety metrics.

B. Application Qualification Templates

Define application-specific qualification templates for (i) grid ESS, (ii) telecom/data center backup, (iii) motive power/cold warehouse, and (iv) low-voltage automotive auxiliary.

C. Safety, Transport, and Incident Reporting

Develop an SBIG safety briefing aligned with UN 38.3 and stationary standards pathways; propose a shared incident reporting taxonomy.

D. Manufacturing and Ramp-up KPI Playbook

Compile a non-proprietary KPI set and best practices for yield, OEE, scrap management, and early defect detection, leveraging broader battery ramp-up learnings.[3][6]

E. Policy and Standards Engagement

Coordinate SBIG engagement on 45X/48E eligibility questions and FEOC documentation expectations; maintain a standards roadmap.

F. Neutral Market Monitoring

Maintain a quarterly SBIG market tracker summarizing capacity announcements, deployed projects, and pricing signals (Na-ion vs LFP), with transparent assumptions.

G. Thermal safety workstream:

Develop a cathode-family thermal stability testing and reporting guide (ARC/DSC/TGA), including minimum abuse-test conditions by application segment and data templates for gas evolution and oxygen release.

Appendix A. Data tables used for figures

A-1. Global market size (historical). Source: internal market synthesis.[1]

Year	Market size (USD, millions)
2018	15
2019	25
2020	40
2021	85
2022	195
2023	350
2024	950
2025	1820

A-2. Global market size (forecast points). Source: internal market synthesis.[1]

Year	Market size (USD, billions)
2025	1.82
2027	4.18
2030	10.47
2032	17.15
2034	28.80

A-3. Indicative segment shares (2025). Source: internal market synthesis.[1]

Segment	Share (2025)
Na-ion cell (2022)	52%
Li-ion cell (Apr 2024)	18%
Na-ion pack (2022)	15%
Li-ion pack (Apr 2024)	15%

Appendix B. Cathode thermal stability summary (from literature review)

Table B-1 reproduces a simplified cathode-category summary based on the Wang et al. thermal stability review.[15]

Cathode category	Dominant runaway causes (high level)	Key influencing factors (examples)
Layered oxides	Phase transitions; oxygen release; coupled exothermic reactions	Na content; structure type (O3/P2/P3); TM ratio/valence; depth of (de) sodiation; electrolyte oxidative stability
Tunnel-type oxides	Mn disproportionation; Jahn–Teller-driven instability	Mn valence distribution; tunnel ordering; Na site occupancy; cycling conditions
Polyanionic compounds	Interface/CEI decomposition and side reactions (often lower intrinsic exothermicity)	Anionic group type; interfacial thermal stability; possible anion migration (e.g., F−) under stress
Prussian blue analogues	Water release; framework decomposition; gas evolution	Crystal/coordinated water content; vacancy ratio; crystallinity; humidity exposure

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